U.S. COAST GUARD
Eighth District
GUARDIAN OF THE HEARTLAND

LOGANEnergy Corp.

Initial Report FY'01 CERL PEM Demonstration Program
US Coast Guard Station PEM Project
New Orleans, LA
January 3, 2003

Table of Contents

Table of Figures

Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the fuel cell power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small scale fuel cell generators will soon be ready to tackle thousands of residential and small scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, assisted by a significant DOD investment, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner, highly efficient fuel cell/hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide Btus for heating and cooling loads-demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy through its FY'01 PEM Demonstration Program to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small-scale fuel cell at New Orleans, LA Lakefront Operations Center of the US Coast Guard. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,
2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,
3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,
4. Measuring the cost of operating a PEM unit under real market conditions,
5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.
6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by the Coast Guard Station New Orleans Operations Center, Plug Power and Energy Signature Associates.

Coast Guard, New Orleans, LA PEM Site Selection and Installation

In February 2003, Logan and Keith Williams of LOGANEnergy met with Petty Officer George Dunn at the US Coast Guard Operations Center in New Orleans to confirm the command's previously expressed interest in hosting a 5 kW PEM Fuel Cell demonstration unit at the facility. Mr. Dunn expressed great support and firm interest on behalf of the command to participate in the program. Subsequently, in May of 2003 LOGAN received supplemental funding under its FY'01 PEM contract to proceed with the PEM Demonstration at the Coast Guard Facility. In early June 2003, LOGAN and CERL conducted the project kick-off meeting at the facility with Coast Guard representatives to cover the objectives of the project and to finalize the installation plan. Plug Power shipped GenSys SN#196 fuel cell to the Coast Guard facility in early July 2003, and on August 27, 2003, LOGAN started the unit for the first time.

Figure 1, Fuel Cell on Pad

Figures 1, above, and 2, at right, are photos of the fuel cell on its pad on the second level deck of the Coast Guard Operations Center. The fuel cell was partially disassembled to accommodate the weight restrictions on the service elevator, then rolled into place with a hand truck and dolly rigged onto the pad with at right, with the assistance of a base fork truck. The electrical/mechanical room is conveniently located behind the louvered wall seen in Figures 1 and 2.

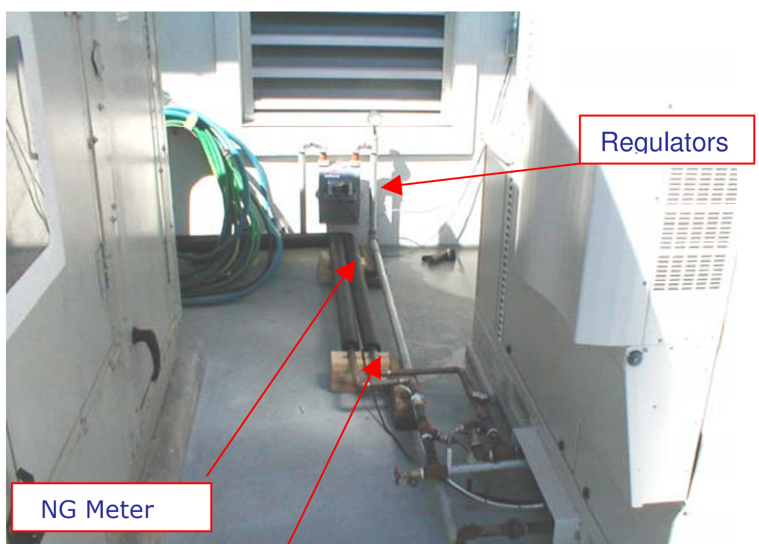


Figure 2, Fuel Cell on Pad View 2

Figure 2, above, also illustrates fuel cell interconnect with natural gas service. The photo shows the gas meter and regulators mounted on the natural gas supply line. It also shows the thermal recovery fluid supply and return lines running between the fuel cell and the water heater located within the electrical/mechanical room behind the louvered panel at the rear of the photo.

Figure 3, at left, illustrates the fuel cell mechanical interface with the facility's domestic hot water supply. A Heliodyne heat exchanger coil, shown attached to the existing hot water, provides a heat transfer interface between the fuel cell glycol loop and the water in the tank.

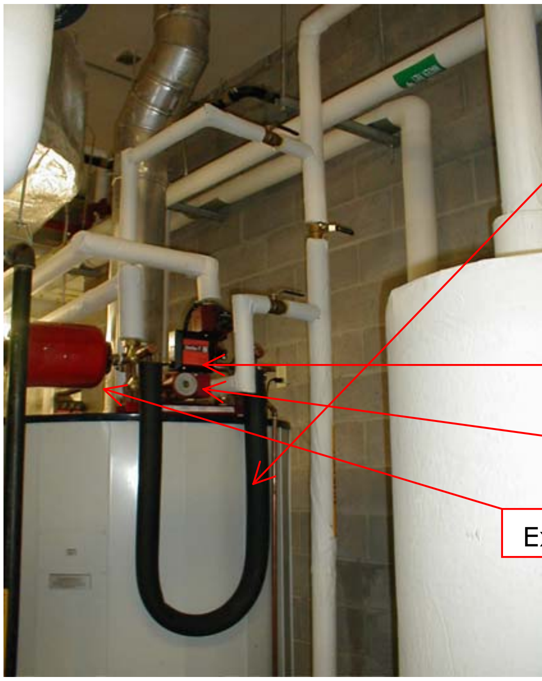


Figure 3, Fuel Cell Mechanical Interface

Figure 4, at right, is a photo of the Connected Energy RTU housing analog and digital instrumentation input terminals and a router to capture and uplink instrumentation data to LOGAN’s Coast Guard Performance Web site. The Ethernet connection has been provided courtesy of the Coast Guard. Data is posted to a view screen similar to the one seen below.

Figure 4, RTU Housing

US Coast Guard Operations Center New Orleans, LA PEM Web Site Performance Screen

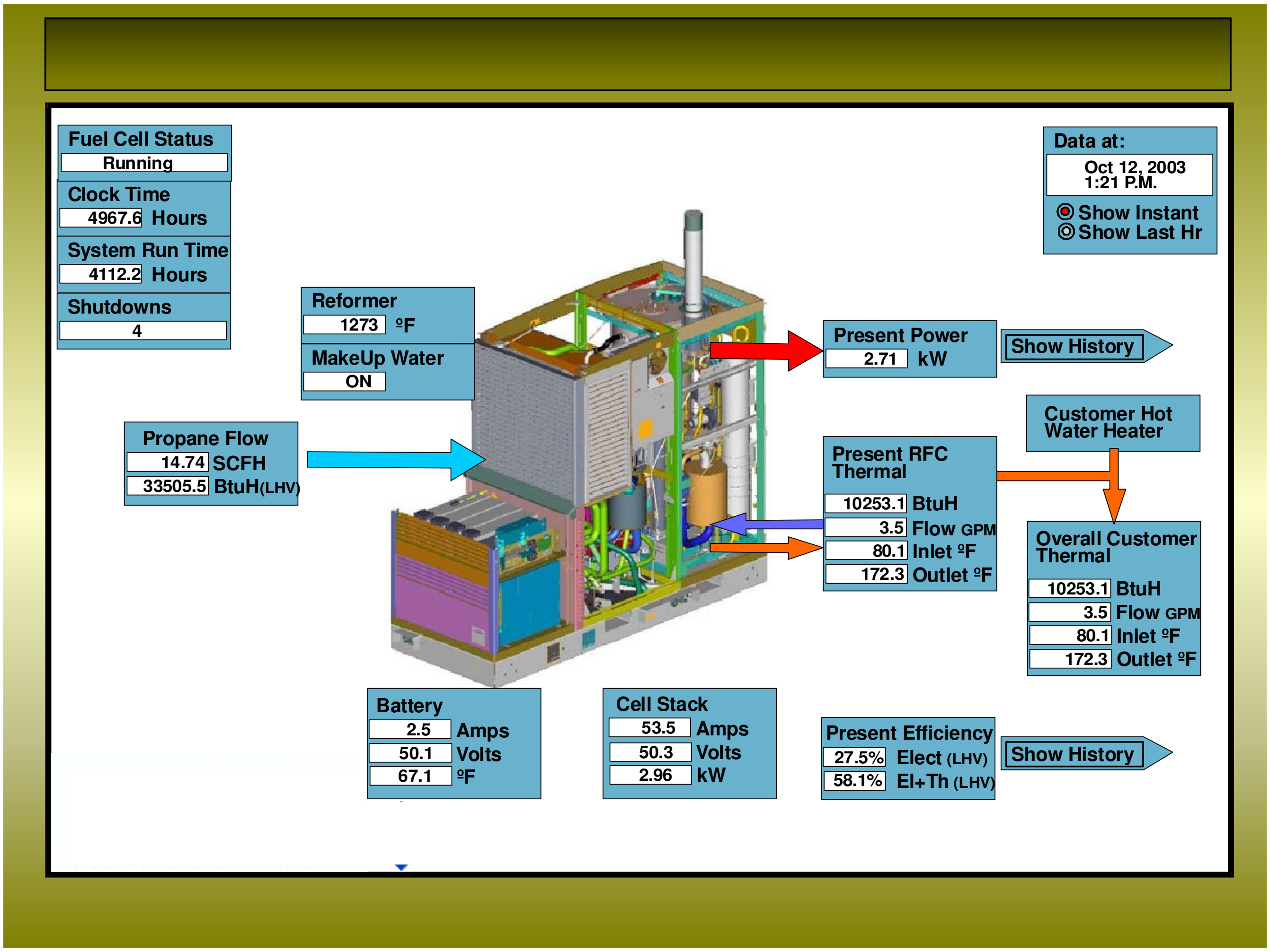


Figure 5, Data Screen

Figure 5, above, is an example of the kind of data screen that will display operating data during the period of performance at the Coast Guard PEM demonstration site. A link will be provided to the ERDC-CERL Web site to allow visitors to browse the site to view the performance screens available to the public.

At right, Figure 6, shows the electrical meter and generator disconnect installed adjacent to the fuel cell. The kW/H meter records both line voltage to the grid parallel service interface and load voltage to the emergency panel.

Figure 6, Electrical Meter

The photo at left, Figure 7, taken in the mechanical room, shows the wall mounted Reverse Osmosis (R/O) De-ionizing Filtration unit required to filter process water before it flows to the water reservoir located in the fuel cell. De-ionized water is required to maintain proper hydration of the fuel cell stack membranes.

Figure 7, Mechanical Room

Coast Guard Station PEM Installation

Installation Line Diagram

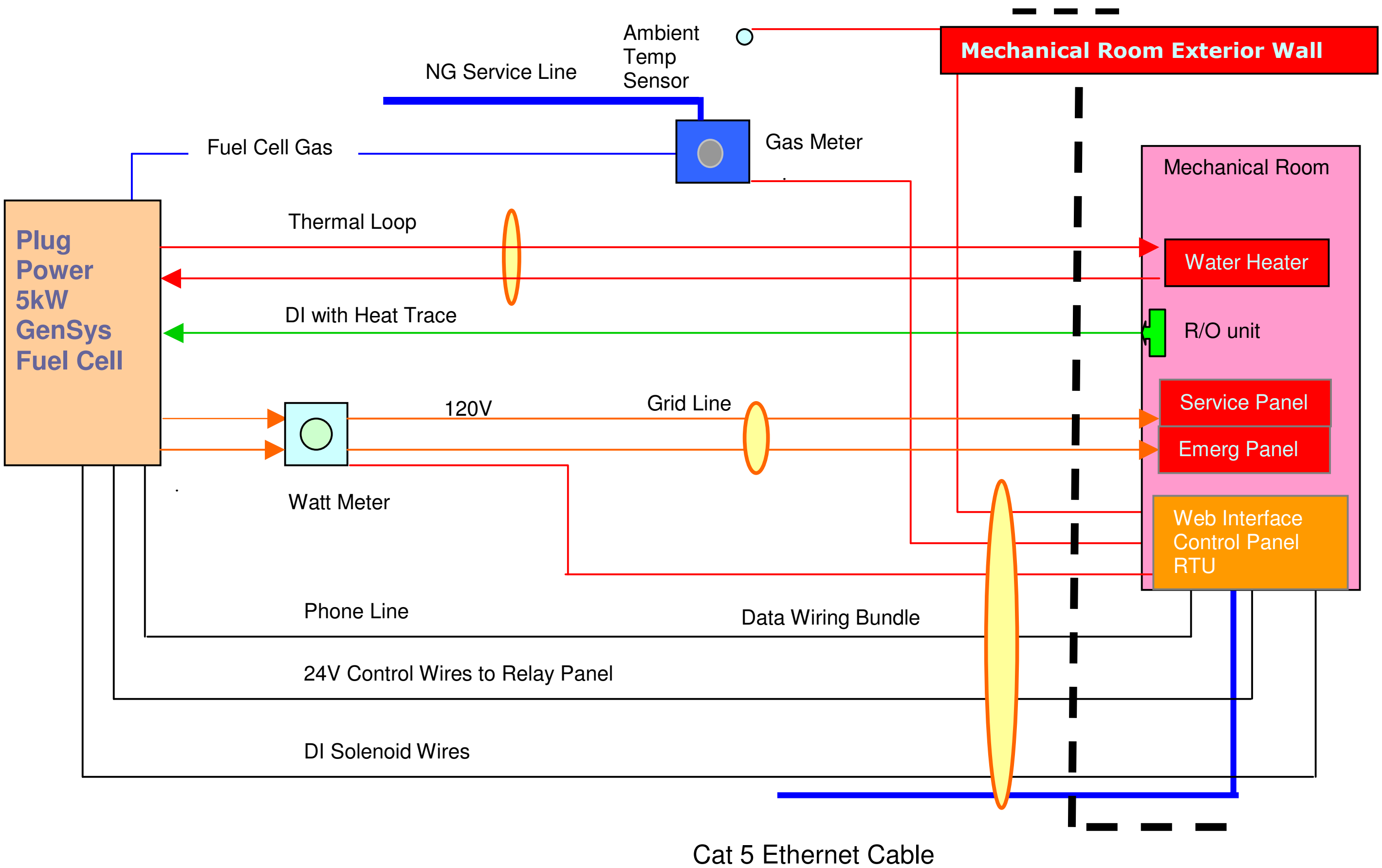
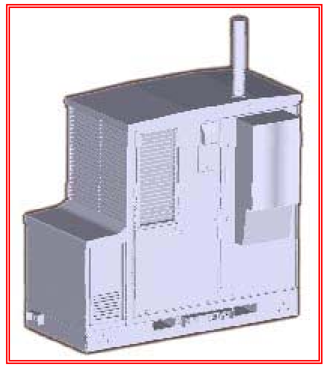


Figure 8, Line Diagram

GenSys5C Product Specifications

Plug Power Fuel Cell System



The GenSys5C is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, the 5C is a clean and efficient source of power.

Specifications

Physical	Size (L X W X H):	84 1/2” X 32” X 681/4”
Performance	Power rating:	5kW continuous
	Power set points:	2.5kW, 4kW, 5kW
	Voltage:	120/240 VAC @ 60Hz
	Power Quality:	IEEE 519
	Emissions:	NO_X < 5ppm
		SO_X < 1ppm
		Noise < 70 dBa @ 1meter
Operating Conditions	Temperature:	0°F to 104°F
	Elevation:	0 to 750 feet
	Installation:	Outdoor/CHP
	Electrical Connection:	GC/GI
	Fuel:	Natural Gas
Certifications	Power Generation:	CSA International
	Power Conditioning:	UL
	Electromagnetic Compliance:	FCC Class B

Dimensions

Length	84 inches
Width	32 inches
Height	68 ¼ inches

Operating Requirements

Fuel Type	Natural Gas
Temperature	0 degrees F to 104 degrees F

Outputs

Power Output	5kW
Voltage	120/240 VAC @ 60Hz
Noise	< 70 dBA@ 1 meter

Certifications

CSA International	Fuel Cell System
UL1741	Power Conditioning Module
IEEE P1741	Grid Parallel Generation

Figure 9, Product Specifications

Installation Application

Figure 8, above, describes a one line diagram of the PEM Fuel Cell installation at the US Coast Guard Operations Center in New Orleans, LA. The diagram illustrates utility and control interfaces including, gas, power, water and instrumentation devices installed in the adjacent mechanical room. Figure 9, above, lists the specifications of the Plug Power GenSys5C PEM technology demonstration fuel cell chosen for this site.

The electrical conduit runs between the facility load panels and the fuel cell are approximately 25 feet. The Reverse Osmosis/DI water tubing run that provides filtered process water to the power plant is approximately 30 feet distance, and the thermal recovery piping runs between the fuel cell and the hot water heater, seen in the photos above, are also approximately 35 feet. After researching several possible heat exchanger options, LOGAN chose the Heliodyne 1100 heat exchanger to transfer fuel cell waste heat to the Coast Guard's 120-gallon commercial hot water heater. The manufacturer provided a packaged unit that was easily plumbed and attached to the hot water tank. Thermal elements were installed in the thermal supply and return lines to measure differential temperatures and a flow meter was added to calculate Btu/H transfer to the hot water heater. Outputs from these instruments as well as from the natural gas meter and wattmeter terminate in the RTU seen in Figure 4 , above. From that point the data signals are processed and routed along a Virtual Private Network (VPN) to the Connected Energy control center in Rochester, NY, where real time operating and performance may be viewed at https://www.enerview.com/EnerView/login.asp. The login id is *logan.user* with a password of *guest*. Then click on the 4th District Coast Guard box.

The Plug Power GenSys 5C fuel cell inverter has a power output of 110/120 VAC at 60 Hz, matching the building distribution panel in the mechanical room with its connected loads at 110/120 VAC. The installation includes both a grid parallel and a grid independent configuration as described in Figure 8, above. The unit provides stand-by power to a new 100amp critical circuit panel that serves several kitchen appliances and other plug loads. A two-pole wattmeter monitors both the grid parallel and grid independent conductors to record fuel cell power distribution to the existing service panel and the new critical load panel.

LOGAN connected the fuel cell gas piping into the existing service line adjacent to the fuel cell pad, and installed a gas meter to calculate fuel cell usage as indicated in Figure 2. A regulator at the fuel cell gas inlet maintains the correct operating pressure at 14 inches water column.

A phone line connection with the fuel cell modem provides communications with Plug Power and LOGAN customer support functions.

The installation proceeded according to plan that insured minimal inconvenience to the host site.

Permitting

LOGAN worked closely with the Coast Guard to insure the installation satisfied all environmental requirements. No air quality permits were required or issued for this site. Figure 10, below, describes the measured GenSys5C power plant emissions.

Emissions information for the Plug Power GenSys 5C fuel cell system

The information below is based on the Eastmount 3rd party emsisons testing circa 1Q01

Start-up condition (worst case)

Efficiency = 15.72%

	CO	NO	NO2	SO2	CH4	CO2	C3H8
lb/MW-hr	3.9983E-02	1.2663E-02	2.1087E-02	2.7034E-02	6.1991E+01	2.5909E+03	6.1239E-02
PPH (@2.5kW)	9.9959E-05	3.1657E-05	5.2718E-05	6.7586E-05	1.5498E-01	6.4772E+00	1.5310E-04
PPH (@4.0kW)	1.5993E-04	5.0651E-05	8.4348E-05	1.0814E-04	2.4796E-01	1.0364E+01	2.4496E-04
PPH (@5.0kW)	1.9992E-04	6.3314E-05	1.0544E-04	1.3517E-04	3.0995E-01	1.2954E+01	3.0620E-04

Steady State

Efficiency = 25%

	CO	NO	NO2	SO2	CH4	CO2	C3H8
lb/MW-hr	2.5143E-02	7.9627E-03	1.3260E-02	1.7000E-02	3.8981E+01	1.6292E+03	3.8509E-02
PPH (@2.5kW)	6.2857E-05	1.9907E-05	3.3150E-05	4.2500E-05	9.7454E-02	4.0730E+00	9.6272E-05
PPH (@4.0kW)	1.0057E-04	3.1851E-05	5.3040E-05	6.8000E-05	1.5593E-01	6.5169E+00	1.5404E-04
PPH (@5.0kW)	1.2571E-04	3.9813E-05	6.6301E-05	8.5000E-05	1.9491E-01	8.1461E+00	1.9254E-04

Figure 10, Emissions Measured

Start-up and Commissioning

The first start occurred on October 15, 2003. Prior to starting the unit the items covered in Figure 11, below, were completed. LOGAN's technician will continue to test and monitor the unit in accordance with the factory recommended procedures to insure completion of the items listed in Figure 12, below. Operations testing and tuning of the fuel cell's electrical and mechanical systems will continue to insure smooth and reliable performance. Service incidents and facility calls will be reported on the sample Service Call Report form listed below as Figure 13.

An Economic Analysis of the Coast Guard project appears in Figure 14 below.

Installation Check List

TASK	SIGN	DATE	TIME(hrs)
Batteries Installed			
Stack Installed			
Stack Coolant Installed			
Air Purged from Stack Coolant			
Radiator Coolant Installed			
Air Purged from Radiator Coolant			
J3 Cable Installed			
J3 Cable Wiring Tested			
Inverter Power Cable Installed			
Inverter Power Polarity Correct			
RS 232 /Modem Cable Installed			
DI Solenoid Cable Installed with Diode			
Natural Gas Pipe Installed			
DI Water / Heat Trace Installed			
Drain Tubing Installed			

Figure 11, Installation Check List

Commissioning Check List

TASK	SIGN	DATE	TIME (hrs)
Controls Powered Up and Communication OK			
SARC Name Correct			
Start-Up Initiated			
Coolant Leak Checked			
Flammable Gas Leak Checked			
Data Logging to Central Computer			
System Run for 8 Hours with No Failures			

Figure 12, Commissioning Check List

LOGANEnergy

Service Call Report

SERVICE CALL REPORT

System Serial #:____________________________

SYSTEM INFORMATION

Date:________________________________

Purpose of Service Call ☐Repair ☐Maintenance ☐ECN (Check all that apply)

	Date	Time
Date/Time shutdown	________________	________________

MAINTENANCE / REPAIR INFORMATION

Service Tech Name: ____________________

Travel Man-hours: ____________________

Troubleshooting Man-hrs: ____________________

Repair Man-hours: ____________________

Spare Part Delay Time: ____________________

Work Performed: ____________________

Technician

Comments: ____________________

FAILURE REPORT SUMMARY

Date	Description of Problem	Rpt #	Initials

Figure 13, Service Call Report

LOGANEnergy Corp.

FY' 01 RESSDEM
Coast Guard PEM Fuel Cell Economic Analysis

Estimated Project Utility Rates	
1) Water (per 1,000 gallons)	$1.69
2) Electricity (per KWH)	$0.0675
3) Natural gas (per MCF)	$7.25

Estimated First Cost	
Plug Power 5 kW SU-1	*$65,000*
Shipping	*$2,600*
Installation electrical	*$1,250*
Installation mechanical	*$3,000*
Watt Meter, Instrumentation	*$750*
Site Prep, labor materials	*$925*
Web Enabled RTU and Router	*$8,750*
Technical Supervision/Start-up	*$3,800*
Total	***$86,075***

Assume Five Year Simple Payback	**$17,215**

Forcast Operating Expenses	**Volume**	**$/Hr**	**$/ Yr**
Natural Gas			
Mcf/hr @ 2.5kW	*0.032838*	*$0.24*	*$1,877*
Water			
Gals/Yr	*4918*		*$8.31*

Add Total Annual Operating Costs	**$1,885**
Total Annual Costs (Ammortization + Expenses)	**$19,100**

Economic Summary		
Forcast Annual kWH	*19710*	
Annual Cost of Operating Power Plant	*$0.0957*	kWH
Credit Annual Thermal Recovery	*-0.016489*	kWH
Project Net Operating Cost	*$0.0792*	kWH
Ammount Available for Financing	*($0.0117)*	kWH
Add 5 Yr Ammortization Cost / kWH	*$0.8734*	kWH

Current Demo Program Cost Assuming 5 Yr Simple Payback	**$0.9691**	**kWH**

***NOTE**Does not include allowance for cell stack life cycle costs or service*

Figure 14, Economic Analysis

Project Contacts

1. Project Manager: Sam Logan
   LOGANEnergy Corp.
   866.564.2632
   samlogan@loganenergy.com

2. Project Engineer: Dick McClelland
   Energy Signature Associates
   412.635.8042
   dickmc@telerama.lm.com

3. Field Engineer: Keith Williams
   LOGANEnergy Corp.
   803.635.5496
   mailto:keithwilliams@loganenergy.com

4. Coast Guard POC: MK1 George Dunn
   USCG Station New Orleans
   201 Hammond Hwy
   Metairie, LA 70005
   gdunn@staneworleans.uscg.mil
   (504) 846-6181

5. Plug Power: Scott Wilshire
   518.782.7700 Ex1338
   Scott_Wilshire@plugpower.com

Site Location

Location of Coast Guard Station, New Orleans, LA
200 Hammond Highway
Metairie, LA 70005

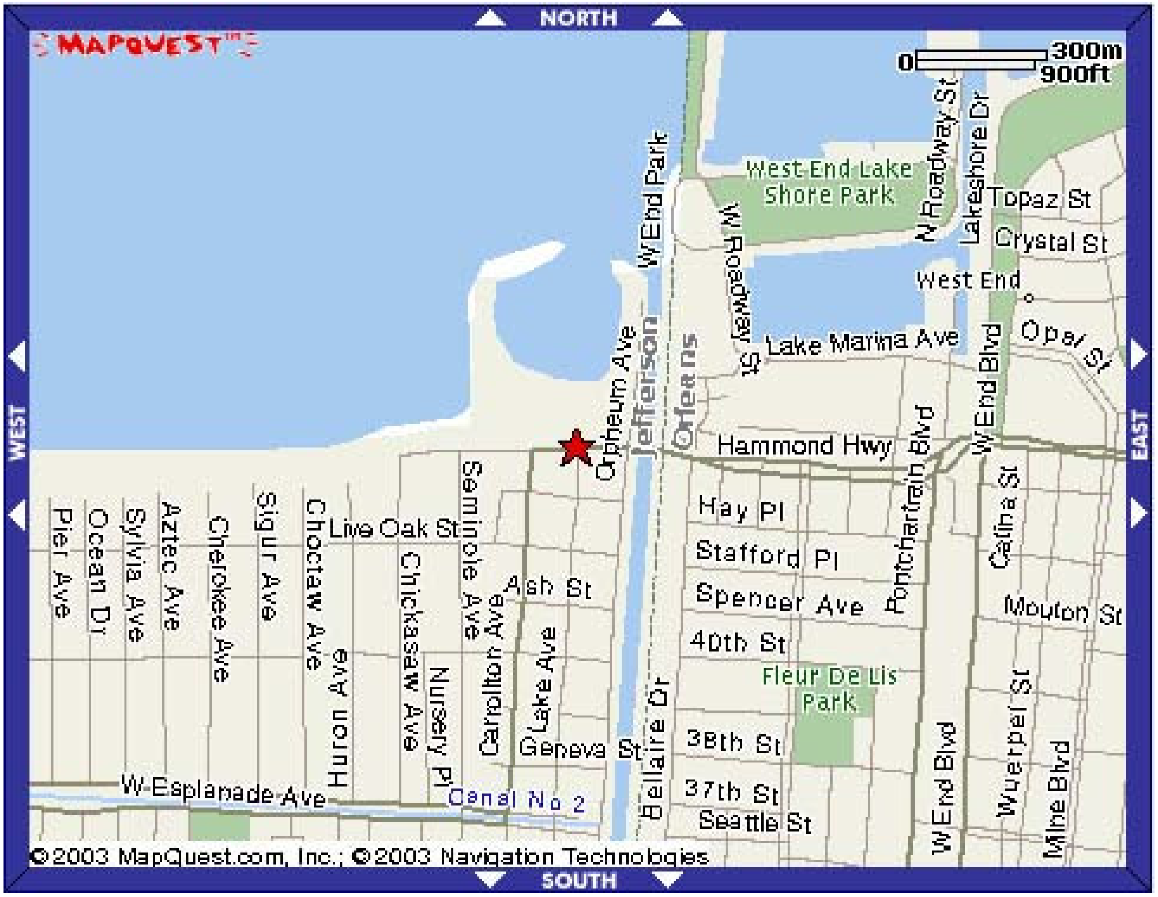


Figure 15, Site Location Map

Coast Guard Installation Safety Plan

LOGANEnergy Corp. Coast Guard Installation Safety Plan

Project Description US Coast Guard Fuel Cell Demonstration Project...Electrical, Mechanical Installation and Thermal integration of Plug Power GenSys5C 5kW PEM Fuel Cell Power Plant .		**Activity Date** Months of October/November 2003
Installation Site 200 Hammond Highway Metairie, LA 70005	**Project Manager** LOGANEnergy Corp. 1080 Holcomb Br Rd 100 Roswell Summit, Suite 175, Roswell, GA 30076	**Prepared By** Samuel Logan, Jr. **Date** 09/25/03
Project Personnel		
Coast Guard Project Mgr. Name CPO G Dunn	**Logan Project Manager** **Name** K. Williams (770) 331-0833	**Emergency Medical Response** East Jefferson Medical Ctr.
Project Contractors Pepo Contractors New Orleans, LA	**Other Personnel**	**Specialized Equipment for Tasks** Fork Truck, Power Drill, Various Power Tools
Installation /Construction		
Tasks	**Perils**	**Mitigation**
1. Run power conductors.	Cut/damage other buried utilities, conduit, lines	Locate and Mark buried utilities before trenching.
2. Connect Fuel Line to Fuel Cell	Release NG to environment.	Practice correct tie-in techniques, use trained personnel.
3. Offload 2,200 PEM Fuel Cell	Damage Equipment, harm/injure personnel.	Use trained equipment operators with trained observers.
4. Electrical/Mechanical Installation	Electric Shock to personnel. Injury or harm working with power tools.	Use "LOTO" procedures; avoid working "HOT" circuits Use trained personnel on all installation tasks.
5. Initial Start of Equipment	Damage Equipment, harm/injure personnel.	Use factory trained personnel, follow procedures.
6. Maintain General Site Conditions	Unkempt Site...Danger to other CG personnel	Remove loose materials, tools, police site at end of each day. Place yellow caution ribbon around installation/work areas.
7. Maintain Safe Work Environment	Injury, loss of equipment, materials, customer	Manager's Representative to encourage safe practices

Figure 16, Safety Plan